

AGRICULTURE-BASED REMEDIATION PROGRAM—TECHNOLOGY DEVELOPMENT AND TRAINING IN BIOREMEDIATION

¹T.Y. Sylva and ²C.M. Kinoshita

University of Hawaii at Manoa, Department of Biosystems Engineering, 3050 Maile Way, Honolulu, HI 96822; Phone: ¹(808)956-8863; ²(808)956-8867; Fax: (808)956-9269.

ABSTRACT

The goal of the Agriculture-Based Remediation Program (ABRP) is to strengthen bioremediation skills locally, nurture a bioremediation industry that can serve Hawaii and other locations in the Asia-Pacific region, assist Hawaii's environmental industry in implementing efficient and cost-effective bioremediation technologies on a commercial scale, and increase public awareness of agriculture-based remediation technologies. Particular emphasis is being given to ABRP-supported projects and technologies; filling critical voids in analytical and other industry-supporting capabilities within the environmental field; and working with the Governor's Millennium Workforce Development Initiative Subgroup on Environmental Science and Technology, which is focused on strengthening the environmental workforce in Hawaii.

The goal for Information Dissemination and Outreach is to provide training to university and secondary-education faculty and government agencies; offer courses and hands-on training in environmental remediation to secondary-school and university students, provide post-graduate professional training; and disseminate information on bioremediation activities that are taking place under ABRP.

Key words: *bioremediation, phytoremediation, environmental remediation, outreach*

INTRODUCTION

Bioremediation — the application of biological processes to address environmental problems — is among the technologies being touted to treat contaminated soils and water sources, and to process wastes. There are significant advantages to using bioremediation over other approaches. Most bioremediation processes can be performed *in-situ*, which reduces cost and disruption to operations, simplifies logistics, and minimizes liability. Unlike many traditional methods that rely solely on disposal or containment, bioremediation usually aims to decompose pollutants, and therefore represents a permanent strategy, minimizing long-term liability.

This report describes the University of Hawaii's component in the Agriculture-Based Remediation Program (ABRP). The ABRP aims to strengthen bioremediation skills locally,

nurture a bioremediation industry that can serve Hawaii and other locations in the Asia-Pacific region, and increase public awareness of agriculture-based bioremediation technologies. Various demonstration projects are underway around the state. The purpose of these projects is to demonstrate the utility of bioremediation technologies on a commercial scale within Hawaii, and to demonstrate that the local industry is capable of implementing efficient and cost-effective bioremediation technologies at military and civilian sites throughout the Asia-Pacific region. These projects include 1) building a constructed wetland to treat sewage waste at a Navy installation, 2) composting sewage sludge and green waste, 3) phytoremediating a pesticide-contaminated aquifer, 4) phytoremediating explosives-contaminated soils, 5) remediating wastewater using ecological engineering, 6) bioremediating

contaminated sediments, and many other projects around the state. Work at the university falls under two categories: (1) Technology Development and Capacity Building and (2) Information Dissemination and Outreach.

TECHNOLOGY DEVELOPMENT AND CAPACITY BUILDING

The primary objective of the first component, Technology Development and Capacity Building, is to strengthen biologically based environmental remediation skills within the environmental workforce of Hawaii. A skilled environmental workforce is needed to support the military and agricultural sectors locally and nationally, and help develop a bioremediation industry that has the capability of sharing technologies and services internationally. By assessing the appropriateness of current bioremediation technologies and the professional pool in Hawaii, resources can be targeted towards strengthening any deficiencies and building upon the strengths. A survey of local environmental companies was conducted and distributed to identify the types of services related to bioremediation that are already available in Hawaii. From this survey, a profile of the technologies and services that are offered by local firms has been compiled and is presented in the Hawaii Bioremediation Database (Figure 1). The database contains a list of companies that offer services in the areas of consulting, contracting, equipment, analysis, and microbe/nutrient distribution within Hawaii. The database also contains descriptions of several bioremediation technologies so that the general public can become more familiar with the terms

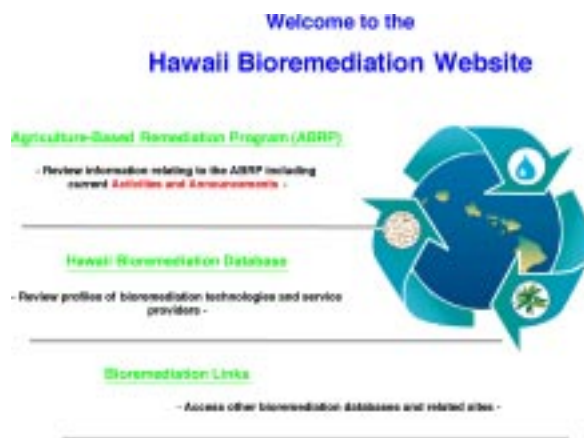


Figure 1. The Hawaii Bioremediation Website (<http://www.hawaii.edu/abrp/>).

and concepts. The database can be accessed at the Hawaii Bioremediation Web site (<http://www.hawaii.edu/abrp/>). This Web site also includes summaries of the various demonstration projects and activities that are occurring under the ABRP program in Hawaii.

A Bioremediation Commercialization Workshop was held in early August 1999. The goal of the workshop was to identify weaknesses and barriers to the widespread adoption and marketing of bioremediation technologies in Hawaii, and to develop strategies and actions that will overcome these barriers (Figure 2). Representatives of industry, academia, regulating, and economic development government agencies were invited. Speakers represented the EPA, mainland and local environmental consultants, all branches of the U.S. Department of Defense, Hawaii's Department of Health, and the University of Hawaii. Presentations covered military bioremediation programs for soil and water resources; regulators', users' and service providers' perspectives on the pros and cons of bioremediation in Hawaii; examples of

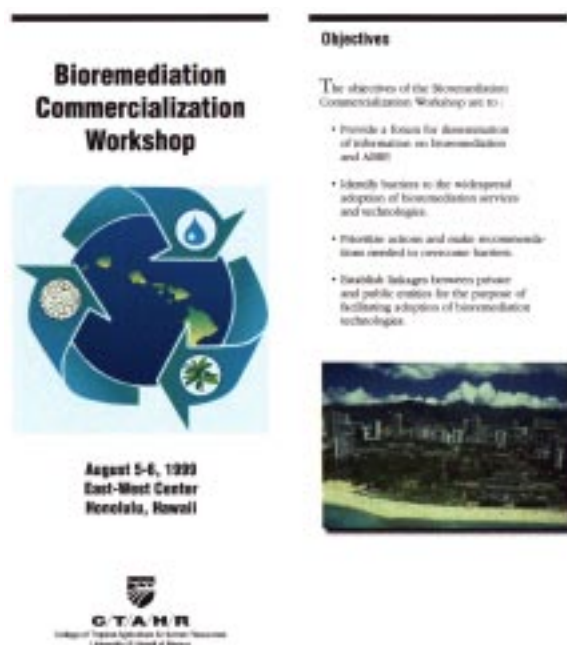


Figure 2. Brochure from the Bioremediation Commercialization Workshop.

successful bioremediation projects on the mainland; and the Agriculture-Based Remediation Program. “Institutional, Regulatory, Technical, and Educational Barriers” and “Solutions for the Commercialization of Bioremediation in Hawaii” were the topics of two panel discussions. The culminating event was breakout sessions where five groups discussed and developed solutions in the following categories: 1) Training and Capacity Building, 2) Technology Development and Demonstration, 3) Industrial, Regulatory, and Public Acceptance, 4) Building Partnerships, and 5) Identifying and Developing New Markets. The presentations and summaries of discussions are being compiled into the Bioremediation Commercialization Workshop Proceedings (to be published).

Application-focused research projects are being carried out to strengthen

bioremediation capabilities and nurture a bioremediation industry in Hawaii. One example is the development of a bioremediation filter, which treats and recycles wastewater from an aquaculture operation. Originally, the wastewater was simply flushed from the system, and replaced with freshwater. The new system allows water to be recycled, thus conserving this important resource, as well as allowing a higher density of fish to be reared and increasing productivity and profit.

Development of Hawaii’s workforce is also the objective of the state program, the Millennium Workforce Development Initiative. In connection with the subgroup for Environmental Science and Technology under this initiative, internships for students at environmental companies are being set up, and training for these interns (e.g. Hazardous Waste Operations and Emergency Response, HAZWOPER) is being offered. These internships provide students with the skills to enter the workforce and the skills needed to strengthen the environmental industry in Hawaii.

INFORMATION DISSEMINATION AND OUTREACH

The primary objective of the Information Dissemination and Outreach component is to provide formal training to educators, government agencies, and the general public on advances in bioremediation, and increase public awareness of the social and economic benefits of environmental restoration through agriculture-based bioremediation. Two new courses offering hands-on training in bioremediation have been developed at the University of



Figure 3. (Left) Teachers learn about research projects being done at the University of Hawaii. (Right) Teachers assemble a natural waste treatment system using plants, rocks, and mud.

Hawaii. The two courses differ in their audience; one course was developed for elementary, middle and high school teachers, and the other for students pursuing engineering careers. The class for teachers includes field trips to bioremediation projects; classroom activities on composting, oil spill bioremediation, water testing, and building model ecosystems that can break down wastes; and guest speakers who lecture on soils, microbes, plants, natural history of the islands, and traditional Hawaiian practices that crossover with the principles of bioremediation (Figure 3). The objective of the class is to train teachers to incorporate a project and/or activities, related to bioremediation, into their classrooms. A network of teachers is developed during the summer session, and teachers may use each other and speakers from the class as resources when needed. The class concludes at the end of the school year, when teachers present (sometimes with their students) their projects and other activities that they have done throughout the year to their peers and other faculty and industrial partners. During this

past year, teachers also presented their projects to professionals from government and industry at a professional conference and at the dedication of a new industrial wastewater treatment facility.

The bioremediation course designed for engineering students covers regulatory, and scientific and design issues for implementing a bioremediation technology in the cleanup of contaminated sites. Students learn about the Resource Conservation and Recovery Act and other regulations that have accelerated the need for this type of technology. They learn about soil, microorganisms, and the complex chemistry and biochemistry that are involved. They also learn about the various designs of systems that use bioremediation, and the mechanisms, such as diffusion and flow, that affect the efficiency of those systems. The laboratory portion of this class includes testing of important parameters within the soil and their effects on biodegradation. The students also visit actual systems that are remediating contaminated aquifers (Figure 4).

Student bioremediation research projects



Figure 4. (Left) Students observe the microbes that “do the work” in bioremediation. (Right) Students visit a phytoremediation treatment unit being used to remediate a pesticide-contaminated aquifer.

are also being carried out at the secondary and college level. As part of a senior engineering design class in the biosystems engineering department, students design novel systems of utility for real-life problems. One example of a bioremediation-related project is the design of a biofilter for the treatment of fumes from a painting facility. The student identified the composition of the fumes traveling through the system, how they degraded, what remained, and designed a biofilter to trap and treat the products.

Some of the secondary school teachers who were enrolled in the bioremediation class had students complete research projects after learning about bioremediation. Students designed systems that treated aquaculture waste using hydroponics systems and aquatic plants. A system that will treat farm animal waste by composting the solids and treating the wash-down water with microbes and plants has been designed and is being assembled.

Other activities include professional development for faculty, and attendance of professional conferences or other training related to bioremediation. Activities that support

such services as contaminant analysis and eliminating deficiencies within the analytical area are already being undertaken. A collaborative project with the city and county of Honolulu will address the commercial use of compost produced from sewage sludge and green waste.

SUMMARY

A wide variety of activities has been initiated as a result of the Agriculture-Based Remediation Program. Many of these activities have already demonstrated the economic viability of this emerging technology, and are designed to build on the technology and develop the capabilities needed to support a bioremediation industry in Hawaii. The university, as part of its Capacity Building and Outreach program, has successfully developed new courses and research projects, as well participated in a variety of other activities which are helping to 1) familiarize the public and private sector about bioremediation; and 2) build a workforce that is knowledgeable and capable of implementing this new technology in the environmental industry.

ACKNOWLEDGMENTS

We would like to thank the Pacific International Center for High Technology, the U.S. Department of Agriculture, and the U.S.

Department of Defense for funding this work under the Agriculture-Based Remediation Program.